

Howard J. Diamond *
NOAA National Climatic Data Center, Silver Spring, Maryland

1. INTRODUCTION

The international Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is cosponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of United Nations Educational Scientific and Cultural Organization (UNESCO), the U.N. Environment Program (UNEP) and the International Council of Scientific Unions (ICSU). GCOS is intended as a long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modeling and prediction of the climate system. It addresses the total climate system, including physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric, and terrestrial processes. More information on the international program can be found at <http://www.wmo.ch/web/gcos/gcoshome.html>.

2. BACKGROUND

Meteorological surface-based networks, utilized for climate purposes, make observations of important climate factors, atmospheric profiles, and pollutant emissions, aerosols, and ozone. These surface-based networks are intended to provide the basic observational set needed to define the status and trends in climate of the world, and also to calibrate and validate satellite-based observations. Although hundreds of millions of dollars are spent each year on developing and operating space-based observation systems, surface-based meteorological networks are "under reporting" their observations in many parts of the developing world because of declining economies and the lack of understanding of how these observations contribute to the global effort to monitor climate. Consequently, these networks are operating substantially below their design standards and important observations are either not being made, or are not being communicated to users. Workshops are being conducted to define GCOS deficiencies and, during the next several years, more detailed activities to improve the networks will be identified. The implementation of a

GCOS Cooperation Mechanism (GCM) was begun in 2004 as a way of identifying resources (both financial and in-kind) to aid in improving the operation of GCOS monitoring stations in developing nations.

As such, NOAA's U.S. GCOS Program Office, which represents the U.S. on the GCOS Cooperation Board, has committed to leading the way for facilitating improvements in the management and operation of GCOS and GCOS-related atmospheric networks. The U.S. GCOS Program Office has taken leadership, working with our partners at the WMO, in further GCOS improvements. This work began in Fiscal Year (FY) 2003 and plans are for continued efforts in this area for the foreseeable future. However, improvements in the various international GCOS networks cannot be done by NOAA alone, and are dependent on matching contributions from other developed nations via the GCM to aid in leveraging and implementing improvements to GCOS networks, and sustaining them. The program reflects a broad-based approach that looks at supporting observing and data management activities at the international, regional, and bi-lateral levels. In addition, support for Pacific Islands Ocean and Climate observing regional coordinators in Fiji and Samoa to aid in coordinating these observing activities among developing countries in the region has been a great boost towards capacity building in that critical region.

The support for developing nations has primarily been for retrofitting surface and upper air observing stations that have up-to-now been silent but yet are key to global climate monitoring activities. Countries that have received new equipment and expendables over the past two years include: Argentina, Armenia, Congo, Cook Islands, Costa Rica, Ecuador, Ivory Coast, Kenya, Maldives, Namibia, the Philippines, and Zimbabwe. In addition to equipment, in cooperation with the U.S. State Department, a number of workshops for enhancing climate change monitoring in support of the Intergovernmental Panel on Climate Change (IPCC) have or are being staged in South Africa, southern South America, northern South America and Central America, Southwest Asia, and Southern Asia. These are all hands-on workshops involving seminars and hands-on work with data from the various countries in attendance. In addition, the State Department has been instrumental in aiding in the establishment of regional GCOS maintenance facilities which have been established in the Pacific and the Caribbean. Another one is being planned for Southern and Eastern Africa in order to further the sustainability of the GCOS network in the developing nations of that region.

* Corresponding author address: Howard J. Diamond, NOAA/NCDC, 1335 East-West Hwy, Room 7214, Silver Spring, MD 20910; e-mail: howard.diamond@noaa.gov.

3. BACKGROUND OF THE U.S. GCOS PROGRAM

The U.S. has been involved with GCOS since its inception. Since 1992, a considerable amount of work has been done by various federal agencies. In particular, federal agencies have supported the international GCOS Steering Committee, and the work of the GCOS data, space, and science panels, as they have engaged in planning GCOS, defining its requirements, and contributing parts of the initial system. NOAA's National Climatic Data Center (NCDC) in Asheville, North Carolina, supports a number of GCOS data management activities and hosts the U.S. GCOS Program Office based in Silver Spring, Maryland.

The primary focus of this office is to coordinate the development of a national GCOS program that involves all U.S. federal agencies with a role in climate observing and monitoring. As part of this effort, the U.S. national program has taken a three-tiered approach to fostering the GCOS program. This approach involves providing support: (1) internationally to improve and enhance monitoring stations in developing nations that require assistance as identified by the international GCOS Atmospheric Observations Panel for Climate; (2) regionally for workshops and projects such as those in the Pacific Ocean region for ensuring a robust and sustainable GCOS observing program; and (3) on a bi-lateral basis with nations that have entered into agreements with the U.S. on improving climate observing activities. The U.S. GCOS Program Office is currently involved in funding bi-lateral climate projects with Australia, China, New Zealand, and South Africa.

Like other developed nations, the U.S. was required to submit a report on the status of its systematic observations for climate. The full report is available at the U.S. National GCOS home page at http://www.eis.noaa.gov/gcos/soc_long.pdf.

4. SUPPORT ACTIVITIES FOR GCOS

In addition to the requirements for national reports on systematic observations, the United Nations Framework Convention on Climate Change (UNFCCC) at its 1999 meeting invited the GCOS Secretariat to continue to assist with and facilitate the establishment of an appropriate intergovernmental process that would identify potential improvements in the global observing system for climate and set priorities for acting on those improvements. As such, the U.S. GCOS program has been one of the leaders in this effort.

The U.S. continues to be an active participant in and large support of the international GCOS program in a number of areas. These areas of support can be characterized in three categories: (1) global; (2) regional; and (3) bi-lateral.

4.1 Global Support

The global support represents the overall U.S. Government's support of GCOS. In May 2002, the U.S. State Department contributed \$600K (US) in funding to

the GCOS Secretariat in order to conduct the second adequacy study of GCOS on a global basis. This adequacy study was called for by the UNFCCC and is a joint GCOS/IPCC effort. This was intended to produce an adequacy report based on among other things the analysis of GCOS national reports in order to focus attention on critical gaps in the overall global climate observing in order for resources to be better directed. Published in April, 2003, *The Second Report on the Adequacy of GCOS* provides a detailed assessment on the gaps in GCOS that provides solid scientific requirements that can be used in resource mobilization towards current and future GCOS support and enhancements. It was planned to be reviewed and endorsed by Environmental and Foreign Affairs Ministers around the world, when presented to Conference of the Parties-9 (COP-9) in December 2003. A copy of *The Second Report on the Adequacy of GCOS* can be found on the GCOS home page at <http://www.wmo.ch/web/gcos/gcoshome.html>. As a follow-up to this report, the GCOS Secretariat in Geneva has developed an Implementation Plan for addressing the gaps identified and that plan is at the same address as the one noted for *The Second Report on the Adequacy of GCOS*.

As part of this global aspect of U.S. support for GCOS, and in response to a U.S. Presidential Climate Change Research Initiative (CCRI), the U.S. has formulated a Framework for International GCOS Support plan. This plan focuses on: the status of GCOS; what is needed to bring GCOS to its operational-design level; and the support needed from the scientific, donor, and host communities to implement selected improvements.

Under the CCRI budget line for the support of atmospheric GCOS networks, NOAA committed to selected improvements in the management and operation of GCOS and GCOS-related atmospheric networks beginning in 2003, and has the leadership, working with the GCOS Secretariat at the WMO, in funding GCOS improvements. In line with that, the NOAA CCRI for the Global Climate Atmospheric Observing System budget for FY 2003 allocated a total of \$3.773M that began to address the most critical needs and deficiencies of GCOS upper air observing sites in Chile, Congo, Cook Islands, Ecuador, Kenya, the Maldives, and Tanzania, as well as the establishment of new aerosol climate observing sites in the Maldives. In addition, this funding was used to: (1) support the operations of the GCOS Secretariat; (2) stage GCOS regional workshops in developing countries; and (3) support critical GCOS data management activities at the GCOS Lead Data Center at NCDC in Asheville, North Carolina. The FY 2004 budget of \$3.787M continued the work begun in 2003 and expanded support to observing sites in Argentina, Armenia, Congo, Cook Islands, Costa Rica, Ecuador, Ivory Coast, Kenya, the Maldives, Namibia, the Philippines, and Zimbabwe. Plans for FY 2005 are dependent on the enactment of an FY 2005 federal

budget, but planning continues on working with our partners in the GCOS community to identify more sites that can be aided.

One issue that the U.S. GCOS program is addressing is the continued operation of the Global Observing System Information Center (GOSIC) located at <http://goscic.org>. The GOSIC has recently completed a second-phase 3-year development effort at the University of Delaware. The U.S. GCOS Office is one of the sponsors of GOSIC along with the NOAA Office of Global Programs. In 2004, a final 2-year transition grant to the GOSIC was awarded, and the intent at this point is for the GOSIC to transition its operation to a permanent operational status at NCDC. During this transition, NCDC will work with international organizations, particularly the IOC's Global Ocean Observing System and the Food and Agriculture Organization's Global Terrestrial Observing System in order to ensure that the data requirements for all three GCOS domains (atmospheric, oceanic, and terrestrial) are fully met during this transition and into the new operations in Asheville.

4.2 Regional Support

While the funding levels are not at the same levels as that of the U.S. global support for GCOS, it is far more focused on efforts dealing with regional workshops for developing nations, with a special emphasis on the South Pacific Island States' region.

The Regional Implementation Workshop, initiated by the GCOS in response to Decision 6/CP.5 of the UNFCCC and held in Apia, Samoa, in August 2000 with support and active participation by both Australian and U.S. experts, built on the South Pacific Regional Environment Program's (SPREP) needs analysis and has provided the basis for development of a Pacific Island-GCOS (PI-GCOS). The PI-GCOS Action Plan has identified the high priority actions, many of which can be implemented as stand alone modules that will assist in restoring and improving observing systems in the region to a level necessary to effectively monitor the climate of the region and systematically detect trends and changes in climate.

The U.S. GCOS Program Office in NOAA has been a supporter of the PI-GCOS effort since the Apia workshop and has contributed resources towards that effort. In FY 2000, the contribution to PI-GCOS was \$25K (U.S.) in support of the workshop; in FY 2001 and FY 2002 the combined contribution to PI-GCOS was an additional \$65K (U.S.) in support of the PI-GCOS Action Plan and Implementation Team meetings, and associated logistics. In FY 2003, support to SPREP amounted to \$105K; the additional funding included support for a data management workshop; as well as some support for related ocean observation work at the South Pacific Applied Geoscience Commission (SOPAC).

In FY 2004 the U.S. GCOS Program Office continued its support of the regional effort, and plans for FY 2005 are to continue this support at levels consistent with previous years. These funds continue to address the actions and proposals from the PI-GCOS Action and Implementation Plans developed over the past couple of years. The U.S. GCOS Program Office also plans to continue contributing in-kind support and facilitation of furthering the goals of PI-GCOS as it has undertaken the role as the Secretariat of the region's PI-GCOS Science and Technology (S&T) Panel. The S&T Panel is a subsidiary body established to provide advice and guidance to the PI-GCOS Steering Committee. In addition to supporting GCOS regional efforts in the Pacific, the U.S. GCOS Program Office has also provided resources to help stage other workshops, as well as in providing presenters on various topics.

In support of the PI-GCOS effort, the GOSIC has developed, in concert with the regional PI-GCOS Program Officer, a new Pacific Islands GCOS portal in order to facilitate the access to Pacific Islands GCOS datasets that may be held in a diverse group of data centers. This portal, located at <http://pi-gcos.org>, has become a key tool to aid in the management of the Pacific Islands Regional GCOS Program, as well as providing an administrative tool for use by the regional program officer. That position is funded by the U.S. GCOS Program Office as part of the integrated Pacific Islands team effort of which the U.S. is an active participant along with Australia, New Zealand, and the member nations of SPREP.

4.3 Bi-lateral Support

In the past year the U.S. (via the State Department) has entered into a number of important bi-lateral climate agreements. Specifically, the U.S. GCOS Program Office is involved in funding projects with Australia, China, New Zealand, and South Africa. These bi-laterals cover a wide range of projects dealing with climate prediction, ocean observing, stratospheric detection, water vapor measurements, capacity building and training, and communication of information, and will focus the attention and resources of all these countries towards developing a more sustainable and robust GCOS program.

In conjunction with the National Institutes of Water and Atmosphere (NIWA) in New Zealand, there are now two new projects which have been implemented on a long-term basis. The first one involves the implementation of a global stratospheric water vapor measurement station in Lauder, New Zealand. Water vapor is a key climate forcing agent, and this new monitoring site will complement an existing site in Boulder, Colorado, which has been taking similar high-quality upper air water vapor measurements since 1980. A second significant project involves the implementation of a new ship track for trace gas measurements that has been implemented on a car carrier ship on a route between Nelson, New Zealand, and Nagoya, Japan.

This is a brand new route and is unique in that it crosses both the Intertropical and South Pacific convergence zones; as such the principal investigators from NOAA and NIWA believe the sampling of trace gases on this route will hold great promise for new and useful data.

In conjunction with the South African Weather Service, the U.S. GCOS Program Office is also working to improve upper air observations in eastern and southern Africa via the establishment of an upper air maintenance and training facility. Joint work also continues on resurrecting the upper air station in Windhoek, Namibia, as well as in upgrading ozone measurements at the Cape Lookout Global Atmosphere Watch (GAW) station in South Africa. A similar ozone measurement enhancement project at the GAW site at Mt. Waliguan in China is also underway via the U.S./China climate bi-lateral agreement.

5. ENHANCED CLIMATE DATA MANAGEMENT IN THE PACIFIC

NOAA has recently taken a closer look at its data management activities in the Pacific Region. The International Pacific Research Center (IPRC) located at the University of Hawaii is a bi-lateral U.S./Japan activity that is funded by Japan, NOAA, and NASA. Specifically, NOAA funding is directed towards the operation of the IPRC's Asia Pacific Data Research Center (APDRC), and the U.S. GCOS Program Office also serves as the NOAA IPRC Program Manager. Links to the IPRC and APDRC can be found at <http://iprc.soest.hawaii.edu> and <http://apdrc.soest.hawaii.edu>.

The vision of the APDRC is to link data management and preparation activities to research activities within a single center, and to provide one-stop shopping of climate data and products to local researchers and collaborators, the national climate research community, and the general public. The mission of the APDRC is to increase understanding of climate variability in the Asia-Pacific region: by developing the computational, data management, and networking infrastructure necessary to make data resources readily accessible and usable by researchers; and by undertaking data-intensive research activities that will both advance knowledge and lead to improvements in data preparation and data products. During the coming year in 2005, the APDRC will address the following activities: (1) operate and continue the development of their Data Server System for serving data; (2) provide a global data archive and necessary data management for climate data and products; (3) conduct value-added activities that produce needed data products; (4) serve as a Global Ocean Data Assimilation Experiment (GODAE) Product Server for a broad range of research and application users with focus on satellite and model-derived products; (5) implement a high-resolution model for downscaling operational models in the Pacific Islands regions; and (6) assess and develop plans, in concert with the program manager at the Scripps Institution of

Oceanography, for the data management needs of the Atmospheric Brown Cloud project (see <http://www-abc-asia.ucsd.edu>)

In September 2004 the U.S. GCOS Program Office staged a workshop in Honolulu to begin some planning for enhancing NOAA's data management efforts in the Pacific. Attendees included all NOAA line offices in the Pacific involved in environmental data management activities, the IPRC and APDRC, the East-West Center, and the U.S. Geological Survey.

The intent of the workshop was to look at how NOAA could begin to enhance its mission objectives to help meet critical regional needs for ocean, climate, and ecosystem information. Objectives are: to protect lives and property, support economic development and enhance the resilience of Pacific Island communities in the face of changing environmental conditions by better integrating regional observations, research, assessment and services; strengthening the delivery of ocean, ocean-related, climate, ecosystem products and services to the diverse Pacific Island user community; and better supporting research and service programs in the Pacific.

This activity also fits in quite well with a Task Team which has been established by the WMO in order to provide guidance and assistance in the designation and implementation process for establishing a Regional Climate Center (RCC) within the region. Such an RCC would aid in supporting climate prediction in the region via a virtual connection of various centers across the region in order to deliver more integrated climate data products and services to users.

6. CONCLUSION

The U.S. has been very supportive of the overall international GCOS program effort and has provided considerable support on both a global, regional, as well as bi-lateral basis. It is believed that support for GCOS should be global in nature and the U.S. is working to be a leader in helping to make GCOS a sustainable and robust system both regionally and globally, and that can serve the needs of an improved global climate monitoring system that will be part of the Global Earth Observing System of Systems (GOESS) being planned internationally by more than 50 nations and 29 international organizations; see the following URL for more details: <http://earthobservations.org>.

The progress that the U.S. GCOS Program has made over the past few years was recently recognized by the UNFCCC. In September 2004, the UNFCCC Secretariat published an In-Depth Review (IDR) of the Third National communication from the U.S., entitled "U.S. Climate Action Report – 2002 (CAR3)". The IDR was performed by an independent review team on behalf of the UNFCCC and is now available on-line at <http://unfccc.int/resource/docs/idr/usa03.pdf>. The CAR3 itself can be found on-line at the following URL:

<http://unfccc.int/resource/docs/natc/usnc3.pdf>. The IDR had a number of findings related to the overall CAR3, however the U.S. GCOS program was specifically identified in findings 130 and 131 on pages 28-29 of their report as follows:

130. The United States has one of the most impressive national Global Climate Observing Systems (GCOS) for climate monitoring in five distinct yet integrated areas. The system acquires detailed local and large-scale national data, including observation of environmental variables, representing a major contribution to the Integrated Global Observing Strategy.

131. The review team was informed that NOAA has formulated a framework for international GCOS support. It focuses on needed improvements to meteorological surface-based networks and on the GCOS terrestrial and oceanic surface-based and satellite-based observation networks. NOAA has identified nine activities that it proposed to launch in 2003 in association with the GCOS secretariat, with a total spending of USD 4 million annually. Additional funding for rescue and digitization of long-period observational data in Africa and Asia is also provided. The provision of these datasets comprises a major contribution to the science of climate change, and is likely to enhance the Intergovernmental Panel for Climate Change (IPCC) process. The review team noted a NOAA initiative for the development of radio and Internet-based climate information dissemination tools for rural farmers in developing countries.

In summary, the inception of the U.S. GCOS Program Office in 1999, coupled with the resources provided via the CCRI program has led to a robust and active U.S. GCOS program which has been working with a number of partners in order to provide support across a broad range of international, regional, and bi-lateral climate activities that are leading to progress for GCOS.